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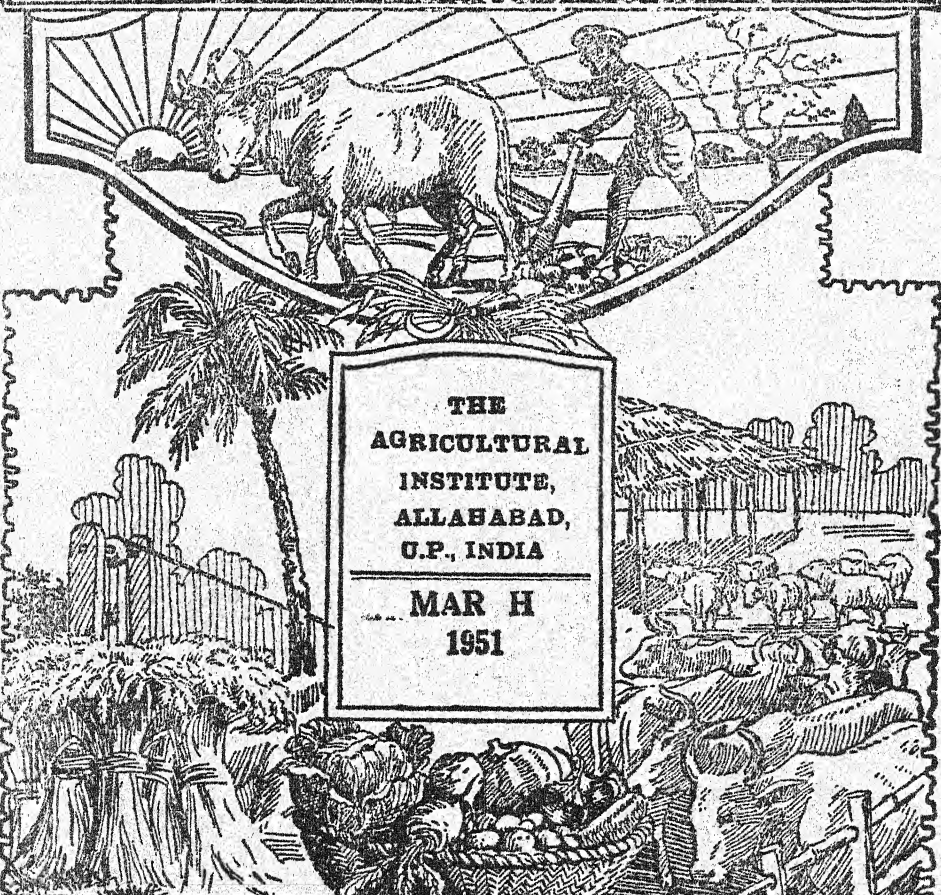

"Whatsoever a man soweth, that shall he also reap."

—*Galatians 6 : 7*

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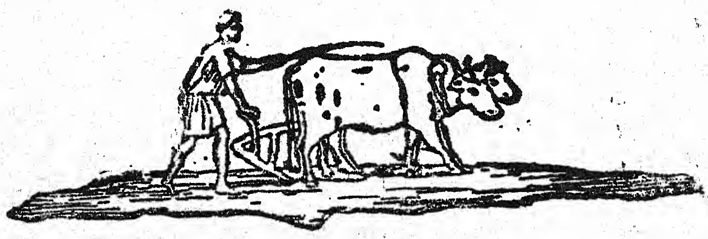

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RE-DESIGNING INDIAN AGRICULTURE

By

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Though there have been some significant changes in recent decades, Indian Agriculture still follows rather closely the ancient pattern obtaining centuries ago. The kind of crops, the varieties, the way of preparing the seed bed, sowing and harvesting have remained essentially unchanged. A few new crops, notably maize, and a few vegetables have come into wide use ; a few new varieties, notably the improved sugar canes and wheats, have more or less displaced the ancient varieties. Little change has as yet occurred in the rotations followed or in the implements commonly used.

Conditions have greatly changed. In the last 150 years the population has more than doubled and is still increasing at a rapid rate. Political changes have also reduced the area which in the past has provided a surplus of wheat to the present area of India. Various conditions have contributed to changing the diet of the people, at least the diet they would like to have. Other aspects of life have changed—increased transportation facilities have made moving round the country easier, the "lalten" or hurricane lantern, the bicycle, safety matches, mill made cloth, soap, many new industrial products have come

into common use. Further changes seem inevitable and desirable in the various aspects of life. Should not agriculture look forward to such a change also, on a scale much greater and at a faster rate than has been evident in the past ? Modern conditions seem to demand such a change.

Previous articles by me have discussed the implications of changes along certain lines, particularly the implications of mechanisation and related problems. At the risk of being considered out of my proper field, I propose in this article to discuss some changes in crops and rotations which seem to me desirable and possible. These have implications which concern the agricultural engineer. Some of them may require the provision of different types of implements. Some of them may encourage or limit the type or implement to be used or may affect the time and method of using an implement. I justify my interest and concern in the problems to be discussed partly on these considerations and partly on the fact that I am interested in and concerned about all phases of agriculture and of rural life as an individual, if not professionally. Also I had a general training in agriculture and lived on a farm before I became an agricultural engineer.

Before we discuss specific changes, let us discuss briefly the changing or continuing needs which changes in agriculture should supply. The pressing need at the present time is for an increase in food grains as that is where shortage is being felt. There is an acute shortage of vegetables, fruit and animal products to *improve* the diet, as well as for the contribution they can make to *increasing the food available.* The need to improve the diet, possibly with the exception of animal products, particularly milk and butter, is probably less felt but none the less real. The shortage in fibers and other non-food crops is perhaps not so acute but there is no room for diversion of land from fibers and such necessities to food grains and other direct food products. Possibly some land could be diverted from tobacco, but any diversion of land from this class of product will be needed to provide for increasing need as the population increases.

At present a very small percentage of land is devoted directly to the production of fodder or feed for livestock. Most cattle at present are fed on waste and byproducts of food crops. Increased feed for the animals cannot be had by diverting land now used for other purposes to feed production. Feed per animal can be increased by reducing the number of animals kept or by intensifying cultivation or both.

The basic rotation in the Ganges valley is a two year rotation with two crop seasons each year. A mixed crop of sorghums or millets with inter-planted legumes is planted in the rains of the first year, with some of the legumes carrying on through the ensuing cold weather to be harvested with the winter crops. The next year will have fallow in the rains followed by a grain crop in the winter, which may be a pure small grain like wheat or barley or a mixture of small grains with legumes or a pure legume. This applies to unirrigated tracts. Under irrigation, crops like sugar cane may be introduced or a crop may be introduced in the place of fallow in the rains in the second year. In the basic rotation, changes may be made by the addition of a crop instead of the fallow or by substitution of new crops for those now grown. Where adequate irrigation is available and the fertility permits, an additional crop can at least in some years be worked in during the hot dry weather. Since the basic deficiency in the Indian soil at present is organic matter, consideration may be given to the possibility of introducing some crop or crops into the rotation which will improve the organic matter content and thereby increase the yield, possibly enough to off-set any reduction in crop area. Two places where such crops can be inserted are, first in the fallow period of the second year of the rotation before wheat or small grains ; second, as a substitute for the continuing legume crop after sorghum or millet. The latter may be either a strictly green manuring crop, as sann hemp is used in the rains, or it may be a forage crop to be grazed by the animals, thus returning the urine and droppings directly to the fields, from which their substance was taken.

The first change I would suggest in the rotation is the insertion of a green manuring crop in the rains of the second year. To do this successfully and without increasing labor and power difficulties, it will be necessary to plow the land the preceding dry weather or as early as possible after the harvest of the previous crop. To start with, the green manure crop may be *sann* (*Crotalaria juncea*). This will, in addition to plowing the previous season, require a soil inverting plow of suitable size for turning under the green manure crop. This substitution or change works very well, with the exception that it is often difficult to get the green manure plowed in at the right time because of continuous heavy rain. Consideration may be given to the possibility of using some other crop, such as cowpeas which may yield a fodder which can be grazed on the spot, turned under, or harvested and fed as a soiling crop. Grazing during the late part of the period and turning under the stubble may give a considerable part of the value of green manuring

and considerable high quality feed. By this means, plowing under can be delayed till nearer the end of the rains. But pasturing the fields when wet may adversely affect heavier soils.

The second substitution or change I would suggest is much more complicated. It has to do with the rainy season crop in the first year. The sorghums and millets now grown are relatively poor in that they give small amounts of direct food grains and the sorghum especially is late maturing. The combination of these with several other crops complicates harvesting in that the different crops mature at different times and must be harvested by hand. The substitution of a crop of maize instead of sorghum or millet will give considerably greater yields of food grain in a short period. If *arhar* (*Cajanus indicus*) is wanted as part of the diet, the possibility of devoting part of the area to maize only and part of it to *arhar* alone or to *arhar* widely spaced in rows with interplanting of maize, may be considered. Preliminary trials indicate that the divided area will give as much or more total yield this way and leave part of the area free of *arhar* during the cold weather. If more than one legume is wanted for food, the possibility of interplanting the *arhar* with the other legumes, such as *urd* and *mung* may be considered, again keeping the maize area free.

The question of use to be made of this area, having maize during the rains, is to be considered. I feel that it should carry a legume during the cold weather which will definitely add to the organic matter and to the nitrogen content of the soil. At present there is no legume that can be recommended with confidence but the desirable features can be listed. I suggest that it should be something which can be sown or planted, with a minimum of preparation, in the stubble of the maize, something which will make a quick growth to cover the soil and continue to grow during the cool winter weather with a minimum of moisture. If it has a deep root system to get down to deeper moisture that will be good. In my opinion, it will be better if this is a pasture crop which can be grazed, possibly by controlled grazing by staking the animals, rather than a crop to be harvested. Any production in excess of the amount the animals can use may be harvested for hay to be used later or it may be plowed down as green manure. If it is sufficiently green, it may be mixed with *bhusa* or other straw or stover as a feed supplement. A desirable feature would be for the seed to lie in the ground and be dormant till the right season and then germinate without the necessity of reseeding each year. A number of clovers have been secured to be tried under these

conditions. When growth stops in the spring and before the crop is entirely grazed, it should be plowed under for manure. In the traditional rotation, this will give two crops of the green-manuring-soil building type following one another. Some modification of the rotation may be considered to avoid this, such as a hot weather crop if irrigation is available or a legume to be harvested in time to plant winter small grain instead of green manure.

Another type of substitution needs to be considered. At present the diet of India seems to depend too much on food grains and not enough on other types of food. Grains have certain definite advantages. They are easily stored, are good food and tasty. Their preparation into food is understood and people are accustomed to them. On the other hand, the total amount of food that can be produced per acre from some other types of crops is much greater. There is a desirable effect from diversity of food in that the diet may be tastier and is likely to contain a better supply of vitamins and minerals if it is varied than if only one or two grains constitute the bulk of it. The various root crops are suitable for substitution for food grains in some instances.

There are several types of root and tuber crops such as potatoes, sweet potatoes and the succulent roots such as carrots, beetroot and turnips, and radishes. Of these, probably the sweet potato and the potato are most important as market crops. Others may be used as catch crops when moisture is available or for family use.

The potato is capable of giving a large yield of excellent human food in the winter season when it would displace small grains and winter legumes. To be profitable, either as a crop to sell or as a contribution to the family food supply, the potato must be planted in the *rabi* season, and requires good land and irrigation. Where possible at least a small patch may well be introduced on every holding for home consumption.

The sweet potato is even more promising. While it has been grown for a long time in India, the varieties are not high yielding nor is the product very tasty. New varieties are available and Dr. Boshi Sen of the Vivekananda Laboratories, Almorah, has done excellent work in introducing, testing and publicising them. The Institute has also recently made further importations of known varieties and of crossbred seed for the development of additional varieties. It is hoped that in the near future, varieties will be available which will give much

greater yields of better quality food than the local varieties now available. Up to now, the sweet potato has been poorly utilised in that only the roots have been used. The vines are excellent cattle food and the growing tips and tender leaves are an excellent vegetable similar to other green "sag". Taking these green growing tips from the vines does not harm the plants unless very heavy plucking occurs. Surplus roots or small thin roots not suitable for human food may be fed along with the vines or dried in the sun and fed as a grain substitute.

The sweet potato has some limitations. The present available varieties are rather long season crops and do not mature early enough to be followed by a second crop of the type of small grains. They may, however, be followed by such crops as pumpkins or *lauki* (bottle gourds) where moisture requirements can be met. Attention is being given to finding an early maturing variety which will get off the ground in time to be followed by some soil building winter catch-crop if possible.

What are the possibilities of fruits and vegetable culture on the small family farm ? Some fruits, particularly papayas and bananas, can be grown in small plaintations to yield a large amount of food. Place for a few plants may be found near the house if some water can be given during the dry season. Some vegetables such as certain types of beans and *lauki* can be grown climbing on the house and with no or very little water and may supply significant amounts of food. If water can be given in even small amounts, vegetables such as the tomato can contribute not only variety but valuable vitamin content to the diet. Even two or three plants, trained to stakes or supports and requiring very little space can meet the needs of a small family, or at least contribute heavily. It must be remembered that the growing of vegetables is a caste occupation and the introduction of exotic varieties may help to break the prejudice. To the extent that the farmer can substitute vegetables in his own diet, he can release food grain for sale to the cities ; if he can also contribute vegetables, even in small quantities per farm, to the market, he not only increases the supply available but increases his cash income available for purchase of industrial products.

A careful study of the above will show that it adds up to a considerable re-design of the traditional type of farming. The suggestions made, for the most part, are given as examples of the kind of change needed, not as the only specific changes. We must change in the direction of getting the greatest production from the land, both in yield per acre of a specific crop

and the largest number of crops in a given rotation period. The crops must be designed to give the maximum of food over the period of the rotation, not necessarily from each individual crop.

Much of the program laid out depends on increased fertility. After 50 years or more of intensive use of artificial fertilisers, we now know that they are effective only when used in connection with adequate organic matter. It has been abundantly demonstrated in repeated trials in America that time and effort devoted to building up the organic matter have paid off in yields of succeeding crops. This is basic to any program of improving yields in India. Much can be done to increase yields by getting better varieties and we should do all possible in this direction. However, in many if not most cases, much more can be accomplished by increasing the fertility than by changing varieties. Both together of course will exceed either alone. Increased organic matter can supply nitrogen and bring about better soil structure, greater ease of working and greater water holding power. To get maximum yields, it will probably be necessary to use chemical fertilisers in addition to increased organic matter but the first step can be taken with the increased organic matter which can be grown on the land with little cash expenditure beyond the cost of seed.

To summarise : Re-designing Indian Agriculture means the adoption of new rotations and the acceptance of new varieties and of new crops. This may involve changing our eating habits, the use of new implements and new procedures. The end result can be an increased supply of more tasty and varied as well as more nutritious food. We need to continually experiment with new crops, new methods of growing them and new methods of utilising them.

AGRICULTURE IN THE CHERRAPUNJI—LAITKYNSEW AREA OF KHASI HILLS, ASSAM

By

B. M. PUGH.

INTRODUCTION.

Cherrapunji is a fair-sized village, and is the capital of the Cherra State, one of the bigger states in Khasi Hills. Cherrapunji is situated at an elevation of about 4,300 feet above sea-level in the southern portion of the Khasi Hills plateau whose elevation is about 4,000—6,000 feet and which constitutes the major portion of Khasi Hills. This southern portion of the plateau in which Cherrapunji is situated is about 4,000 feet in elevation above the plains of the Sylhet District. The village of Cherrapunji receives an annual rainfall of about 450 inches.

Laitkynsew, a village about 8 miles to the south of Cherrapunji is situated on a small plateau which is surrounded on almost all sides by precipitous cliffs and very steep slopes. The height of the plateau is probably about 3,000 feet above sea-level, and the amount of rainfall may be about 300 inches annually. Laitkynsew village belongs to Nongkhlaw State, another state in Khasi Hills.

The present report deals with agriculture only in Cherrapunji and its immediate vicinity including the villages of Mawsmai, Mawmluh, Sohrarim and Mawkdok (or Dumpep), and in Laitkynsew and the surrounding areas including the villages of Nongwar and Mawlong; that is, only those areas which I have had occasion to visit in the course of my tour. The tour was cut short due to incessant rainfall. The report is therefore sketchy and incomplete.

The Cherrapunji area under report seems to belong to two agriculturally somewhat different regions which I wish to call the northern plateau in which the villages of Sohrarim and Mawkdok are situated, and the southern plateau in which Cherrapunji, Mawsmai and Mawmluh are situated. The Laitkynsew area under report includes the cultivated fields on the Laitkynsew Plateau and the adjoining slopes below the plateau.

CROPS GROWN.

In the northern plateau the potato is by far the most important crop grown. Other crops grown to some extent in this area are maize, *Sohphlang* (*Flemingia vestita*), Broom-corn millet (*Panicum miliaeceum*), fox-tail millet (*Setaria italica*), sweet potatoes, upland rice, and *Rymbai Ja* (*Phaseolus calcaratus*).

In the southern plateau, vegetables (mostly green peas and cabbages) are the most common cultivated crops. Potatoes, *Sohphlang* and maize are some of the other crops grown.

In the Laitkynsew area the crops grown vary with the elevation and topography of the area. On the plateau itself where wet terraces can be made, rice is a common crop. On the sides of the hills, which are on the top of the plateau, there are coffee plantations which were deteriorating but are being resuscitated. On the slopes below the plateau various types of plants are grown, such as the pan leaf (*Piper betle*), orange, various other kinds of citrus fruits, jack fruit, betle nut, black pepper, banana, pineapple, papaya, and many plants which either grow wild or are cultivated and which produce commercial products and are therefore sold in the market, such as *Sohmrit Khlaw* (*Piper longum*) and bay leaf (*Cinnamomum obtusifolium*).

The potato, as mentioned above, is one of the main crops of the area but is principally confined to the plateau area more particularly to the northern part of the plateau. In the latter area, potatoes may be grown twice in a year, but in different fields. The winter crop is sown in August—October and is harvested in January—April. The summer crop is sown in December—January and is harvested in May—June. In the southern part of the plateau, potatoes may be grown three times a year. The first crop is sown in January—February and is harvested in May—July. The second crop is sown in August—September and is harvested in January. The third crop is sown in November and is harvested in March.

The varieties of potato preferred in the area are: (1) Up-to date, (2) Arran Consul, (3) Windsor Castle, (4) Magnum Bonum, (5) Inverness Favourite, and (6) King of Potato. These varieties may be tried out experimentally under controlled conditions in the two areas mentioned above, and their yields found out. This may give the Department of agriculture data for recommending suitable varieties for these areas. A more careful study of the adaptibility of each of these varieties may also be made with a view to finding out which varieties are suitable. A short description of each of these varieties and other varieties that have been issued by Government from the Upper Shillong Farm would be very helpful to the cultivators, not only in the Cherra State, but in the whole of Khasi Hills as well as in the other hill areas of the North-East Frontier Agency.

Most of the potato in the area is grown by the method which is known as "Jhuming" or shifting cultivation. The land is cleared of jungle or grass, and the sod is then turned upside down with the help of Khasi hoes known locally as "mohkhiew" ("kodali" in Nepali, and "pharwa" in Hindustani). The sod and the soil are built up into raised beds which are about 5′×15′. Between the beds water channels are made which carry off rain water during the rainy season. The beds are about one foot higher than these water channels. The beds run up and down the slope and not across the slope. When the sod is dry and combustible, and just before the beginning of the rains, the sod is set on fire. The grass under sod burns with a slow fire for a period of about two or three days. When the burning is complete, holes are dug in these raised beds at distances varying from 12 to 14 inches. Well-decomposed cow manure is then put in these holes and potato seeds are then dropped in each hole. The potato grown in this way is known as "phan bun", referring to the method of preparation of the field, or "phan lum" (field potato), as distinct from the garden potato. Garden potatoes are those grown in permanent gardens which are usually terraced. The potato grown in this way is known as "phan kper". Potatoes in these gardens are grown from year to year and not after an interval of several years as in the case of field potatoes. Some cultivators are of the opinion that potatoes grown in gardens suffer from disease more than those grown in the field. There seems to be some truth in this contention. The following may be the reasons for this phenomenon: (1) In garden (*i.e.* terraced) soils, as potatoes can be grown from year to year in the same field, the organism causing the disease may live from one year to another. It would be advisable, therefore, for the cultivators not to grow potatoes in their garden soils for about three or four years if a potato disease has appeared in the potato crop grown in these soils, (2) Garden soils are not so well drained as fields soils. Such conditions also favour the spread of the disease. Cultivators should therefore provide proper drainage in garden soils, (3) Heating the soil by burning dried leaves or grasses may kill the organism causing the disease, as the organism is known to die even at a temperature of about 120° F. The garden method of planting potatoes is however a better method as it allows a more or less permanent cultivation in stead of the shiting cultivation which is so very destructive to the soil as it facilitates soil erosion. Even if cultivators would zig-zag those beds and have them run parallel to the contour of the field in stead of up and down the slope,

much of the good surface soil would be prevented from going down to streams and rivers and ultimately to the sea. Potato cultivation with the "jhum" system is mainly responsible for the present impoverished state of the Khasi Hills due to the removal of the top soil. The Cherra State is now denuded of most of its cultivable soil and therefore possesses little except bare hills which can only become cultivable once again after years of systematic afforestation and through the prevention of wanton burning of indigenous grasses and shrubs.

Potatoes sprout in about ten days after sowing. During the season the potato plants are earthed up two or three times. This is also done by means of a small Khasi hoe. This earthing up also helps control weeds, and aerates the soil. This last is probably necessary as it is believed that potato roots need oxygen for their proper development. The amount of seed sown per acre is about 10 to 12 maunds. This high seed rate is due to the fact that larger tubers than those commonly used in the plains are used in these hill areas for seeds. When the crop is ready for harvesting, the "mokhiew" is again used for digging the potatoes. The normal yield is about 80 to 100 maunds per acre.

While the potatoes during the time I visited the area (second week of May) seemed to be quite healthy, yet several diseases were detected which, I understand, did a great deal of harm in other years to the potato crop. The most injurious of these diseases seems to be a blight caused by a fungus known as *Phytopthora infestans*. This causes the sudden droopping of the stems and leaves and gives them a black or dark appearance. This disease may be controlled by spraying with Bordeaux mixture (5 lbs. of copper sulphate, 5 lbs. of lime and 50 gallons of water, all mixed in some wooden vessel), or with Pyrenox. Certain preventive measures may also be adopted in order to control this disease: (1) Only a potato from a healthy crop should be used for seed, (2) Government may take upon themselves the responsibility of growing potatoes for seed purposes, and sell only potatoes which have been known not to suffer from blight, or they may certify certain potato growers as potato seed growers. Fields of certified seed growers would, therefore, be always subject to inspection by Government.

Another disease that seems to be quite common is a root disease caused by a fungus known as *Rhizoctonia solani*. Plants at various points on a field are noticed to droop suddenly and after a few days they die completely. This is due to the attack of the above organism on the roots until the injury reaches the

conducting tissues, thus stopping the flow of water from the roots to the stem. Unlike the plants that were attacked by blight which seemed to have been attacked *en masse*, the plants which suffer from this disease were attacked singly and in various parts of the fields. The higher lands which contained less organic matter or which were perhaps better drained than the lower lands seemed to have had more plants attacked by this disease. In this respect the conditions causing the incidence of this disease seemed to be different from those which caused the occurrence of blight. Plants attacked by this disease can, for the present, only be taken out and destroyed, so that the organisms do not spread in the soil through these diseased plants.

Another disease that seemed fairly common is one known as mosaic which is caused by an ultra-microscopic organism known as a virus. This causes the leaves to curl and the plants to be dwarfy. This disease may be responsible for the so-called deterioration of seed potatoes. The disease may remain in the tuber and continue to increase from year to year, so that in a few years the yields obtained from seeds of these diseased tubers are very much less than those obtained from new imported seeds.

Only one insect pest, locally known as "nyang pulit" (*Cantharis sp.*), a red headed blister beetle with a black body, appears seriously to injure the crop. This may be controlled by spraying with D. D. T. powder or other insect sprays now available in the market.

Sohphlang (*Flemingia vestita*) is another important crop in the area, but is confined to the Cherrapunji plateau only. It very often follows a potato crop and is therefore grown in the second year in "Jhum" fields. The crop is sown in February—May and is harvested in August—November. About 4 maunds of seed in the form of small tubers are sown per acre, and this yields from 30 to 40 maunds.

This crop is peculiar to the Khasi Hills, Assam. It is not grown, as far as I know, in any other part of Assam or India. The plant is small and usually bears numerous stems which are somewhat straggly, and grow to a height of a few inches only, say 8 to 10 inches. The portion of the plant that is eaten is the soft and white tuberous underground stem just below the crown. This is eaten raw after washing off the upper part of the skin by constant rubbing in water or after peeling the skin as it is somewhat pungent. These tubers contain mostly starch but

may also possess a fair amount of protein as the plant is a legume.

The disease that is said to attack the crop sometimes, is one that affects the skin of the tubers, giving them a dirty colour. The tubers attacked by this disease are also very disagreeable to taste. When damage is serious, the tubers begin to rot. The disease may be related to the scab disease of the potato. If this is true, this crop should not follow potatoes in rotation.

Maize is also an important crop, especially in the Cherra plateau. The crop is grown usually in gardens and only occasionally in "jhum" fields. It is sown in April and reaped in October—November. Two varieties are mostly grown, the "Dem Lieh" or White variety of flint maize, and the "Dem Stem" or yellow variety of flint maize. "Dem Saw," a red variety, is occasionally found, but is not popular.

The crop is a vegetable, but if harvested when fully ripe, the grain is used as cereal. A portion of the crop is also used for making a liquor which is preferred to rice liquor but is not considered as good as the liquor obtained from finger millet.

In the Laitkynsew area wet rice is grown only on the plateau. In the Cherra area, upland paddy is occasionally sown in "jhum" fields. The latter is therefore not important. At Laitkynsew the paddy sown is always transplanted. At Laitkynsew, seeds are first sown in a wet or moist nursery in the beginning of April. When the seedlings are about six or seven weeks old, they are transplanted into wet terraces which have been prepared, just before transplanting. The preparation of these terraces consists in turning over the sod and letting water into them to facilitate puddling. This is done by treading with the labourers' feet. Two or three seedlings are put at each point at a distance of about 6 or 8 inches from one point to another. The field is then left submerged, at a depth of about four to five inches, throughout the growing season. No other care is given to the crop. It is then ready for harvesting in November or December. While there appear to be two varieties commonly grown in the Laitkynsew area, the White and the Red grained, the local people seem to prefer the White to Red for eating purpose. Paddy is grown from one year to another in those terraces as otherwise the soil becomes quite hard and more difficult to work if left fallow even for one year. Paddy soils at Laitkynsew are very deficient in humus. The addition of organic matter in the form of farm manure or compost from village

wastes, or of leaf mould, would greatly add to the meagre amount of organic matter now present in the soil.

The loose-skinned orange (*Citrus reticulata*) is the most important fruit crop of the Mawlong and Nongwar villages which are situated on the slopes and which are respectively to the east and west of Laitkynsew village. The orange area of these villages is part of the citrus fruit area on the southern slopes of the Khasi Hills which is also the region where the so-called Sylhet orange is grown.

The method of growing oranges in this area seems to be as follows :—

Seeds from fully ripe fruits obtained from old and healthy trees are collected and are sown in small beds which are rich in organic matter. Seeds are sown on the first onset of the monsoon rains which is usually in the month of February or March. When the seedlings are about 4 months old, and when the monsoon season is well-advanced, the small seedlings are transferred to another nursery, usually in the middle of an orchard, where these seedlings are to be planted ultimately. The seedlings in this new nursery are planted at a distance of about 14 to 16 inches apart. Here they are left for a year or two until they are ready to be transplanted finally into an orchard. Occasionally there is one more transplanting before they are finally transplanted, so that they may be transplanted up to three times. The distance of planting in the orchard is only about 8 to 12 feet which seems very close for most varieties of oranges and for most orange growing areas ; but the orchard that I saw did not look very crowded although I was told that the orchards were about 20 to 25 years old. The very steep slopes on which these orange trees are grown, the poor soil conditions, and perhaps the variety, are probably some of the reasons why these trees can be planted as close as they are now. However, I am of the opinion that orange trees planted at a distance of about 14 to 15 feet would spread out more and yield more fruit than those now planted 8 to 12 feet apart. Orange trees raised from two-year old seedlings begin to bear in the fifth or sixth year after planting. I was told that formerly there were orange orchards which were about 100 years old, but that they now no longer exist. I was told that newly planted orange trees do not thrive well in old orchards.

The orange trees in this area seem to suffer from several maladies which have not been properly studied. One type of

malady is what is generally considered as a "die-back" disease. This disease is characterized by the dying back of the smaller branches from the tip downwards towards the larger stems, and ultimately it causes the death of the tree. The tree affected by this disease generally dies in two or three years. This malady is known locally as "yap yong."

Another malady which may be due to the same causes as those that produce the die-back is the appearance of young and diminutive leaves which later become yellow or bronze in colour which in the course of a year or two cause the death of a tree. This disease is considered by the local people as being contagious as it usually affects a whole orchard. However this may be physiological, the environmental conditions (soil or climate factors) being probably responsible for the death of the trees in the orchard. Other maladies were reported to me, but I was not able to see them in the course of my tour.

Orange trees are also attacked by stem borers, probably all larvae of certain beetles. One of the most troublesome of these borers is *Monohammus versteegi*, Ritz. The larvae or grubs bore into the wood of the tender stems resulting in the withering away of the leaves and the drying of branches which are attacked by these insects. These insects may be destroyed by probing with a wire or by using carbon disulphide or "D. D. T." Powder or "Gammexane."

Scale insects, probably of various kinds, are also very common in the area. They also seem to do a great deal of damage to orange trees. Spraying with kerosine-soft-soap emulsion may be tried out for controlling these insects.

Besides the above diseases and pests, orange trees are occasionally parasitized by a flowering plant (*Loranthus sp.*). This plant propagates itself on orange and other citrus trees by seeds probably deposited by birds carrying them in their beaks or through their droppings. It seems desirable that all orange-grove owners co-operate in destroying these parasitic plants by removing them whenever they can be found.

The most common disease on lemon noted in this area is canker caused by *xanthomonas citri*. This disease attacks leaves and fruits. The leaves thus attacked lose their effectiveness in the manufacture of plant food (*photosynthesis*) and the skin of the fruit becomes rough and consequently disfigured as the result of the damage caused by the organism. Young leaves were the ones most affected. This may be simply due to the

splashing of rain water which might have transferred the disease from the infected leaves to the new leaves, while older leaves which had come out in the dry season might have escaped the disease.

The most important problem in orchard management in this area seems to be the maintenance of organic matter in the soil and the prevention of soil erosion. Methods of controlling weeds in the orchard also seem to be tied up with this problem of maintaining a proper amount of organic matter in the soil. Weeding should be done by cutting the weeds with a "dao" and leaving them to rot and also to cover the soil to prevent the washing of the soil by the rain water. The proper time of cutting the weeds with a view to maintaining the greatest supply of organic matter and preventing soil erosion should also be found out. It is probable that the two diseases mentioned above may be caused by a lack of organic matter in the soil. The addition of organic matter in the form of farm yard manure, or compost from village wastes, or leaf mould, or in the form of a cover crop will greatly improve conditions in the soil.

Budding or grafting is almost unknown in the area. This method of propagation may be more generally demonstrated to the cultivators, as trees propagated by budding come into bearing earlier than those grown from seedlings. But some cultivators are of the opinion that trees from seeds are more vigorous and last longer.

Several other citrus fruits are found in this area in which the orange is grown: Pummelo (*Citrus grandis*) known locally as "soh myngor" ; citron (*C. medica*) known locally as "soh mad" of which there are two types, the giant and the dwarf; "soh myndong," the rough lemon (*C. jambheri*); "soh pai" (*C. limettioides*) ; "soh sying" or "adha jamir" in Assamese (*C. assamensis* Bhattacharya and Dutta)* "soh khyllah" of which there are two types, one of which bears fruit in groups of three or four (probably *C. paradisi*, a grape fruit) and another bears fruit singly ; "soh kulong" meaning an everlasting fruit and is so called because it bears fruit throughout the year, "soh nyang-riang," (*Citrus sinensis*), "soh kwit" or "sat kora" in Assamese, "soh syiem" (a kingly fruit), "soh shrieh" (a monkey fruit), etc. All these citrus fruits at present have little commercial importance. A fairly comprehensive taxonomic study of the citrus fruits in this area would, in my opinion, be of great scientific value not only to India but also to the whole world.

* Bhatlacharya and Dutta call "*adha jamir*" a new species, *Citrus assamensis*. They call *C, aurantium* "karun jamir." They call *C. macro ptera* "sat kara."

Betle leaf (*Piper betle*) is an important crop in the slopes below Laitkynsew. Yet cultivation, for the most part, seems to be haphazard as the vines are planted at the foot of all kinds of trees, or at the foot of such trees as jack, and betle nut palms, which are grown haphazardly in the orchard. Some betle leaf cultivation is more systematic in that the fields are laid out in a special area which is capable of being irrigated from small springs.

The method of propagation consists in taking cuttings from old healthy vines and planting them as stated above, either at the foot of certain trees or in an area in which tree supports are provided. The area in either case, is fairly well shaded, as betle leaf grows better under some shade. These cuttings may be four to five feet long. Shorter cuttings than these may be planted, but they may take longer time to yield mature leaves for the market. The longer stem cuttings may yield their first leaves for the market in about two years. Some cultivators wash the cuttings before planting, as this is believed to prevent the early appearance of a disease which, as far as I can find out, is a blight caused by a fungus known as *Phytopthora parasitica*. If these cuttings are washed in Bordeaux mixture (2 lbs. of copper sulphate, 2 lbs. of lime and 50 gallons of water) or in a solution of Pyrenox the results probably would be better.

Betle leaf receives very little care afterwards except occasional weedings; and, as stated above, irrigating, when such facilities are available during the dry season. Betle leaf vines continue to bear for very many years, probably even up to 40 years, if they are not attacked by disease.

The most dreaded disease on betle leaf seems to be the blight mentioned above. The symptoms of the disease are circular blackish or darkish spots on the leaves, which increase in size, gradually resulting in the rotting of the major part of the leaf. The leaf stalk (petiole) and the stem may also be attacked, giving them a blackish or darkish appearance. The disease may also cause splitting of the bark in the stem. The cultivators are familiar with the disease and are somewhat acquainted with the nature of its spread. For that reason, they usually will not enter their betle leaf cultivation without washing themselves including the clothes they wear. They are also definitely of the opinion that the lower leaves are the ones usually attacked first. For that reason they prefer to allow their vines to climb up very tall trees although this makes it difficult to pick the leaves at the time of harvesting. They are also of the opinion that irrigated plants are more susceptible to the disease than the unirrigated

ones. It is also likely that the fungus causing the disease is carried from plant to plant through irrigation water. Their method of controlling the disease is by scraping the portion of the vine in which the disease appears or by cutting off the portion of the vine that is so diseased. If, after scraping, Bordeaux paste is applied, the disease may be cured. It may also be advisable to disinfect the knife in mercury chloride solution (1 to 1000) whenever it is used to remove a diseased portion of the vine. The disease seems to spread more rapidly during the rainy season. This may be due to the spread of the spores from diseased leaves due to the splashing of rain water. In other words, rain water may be carrying the spores of the fungus from the diseased leaves to healthy ones. Spraying the plants with a 2:2:50 Bordeaux mixture at regular intervals may be tried out for controlling the disease.

"Sohmrit Khlaw" (*Piper longum*) a plant related to betle leaf (*P. betle*) and to black pepper (*P. nigrum*), which grows in a more or less wild state in the Nongwar and Mawlong area, is very much valued for its fruiting spikes which are dried in the sun, as they bring an enormous price in the market. The spikes are bought probably for their medicinal value. As the plant is so valuable, a proper study of its culture is very important. This, I think, has not been done.

The banana is grown in the Laitkynsew-Nongwar area and to some extent in the Mawlong area also. Three types of banana are common : (1) "Kait Syiem" or "Kait Shini" known in Bengali as Chini Champa, (2) "Kait Khun" or "The banana for feeding to babies" as it is not sweet because it contains little sugar, and (3) "Kait Jingka" or "Kait Jrong" the banana with long "fingers". The first is grown at lower elevations of this area, whereas the other two are grown at higher elevations. But of the latter two, "Kait Khun" is grown in medium fertile soils whereas "Khait Jingka" is grown in fertile soils, mostly in garden soils. Even then, the yield of "Kait Jingka" is not as much as that of "Kait Khun" although the fruits of the former are bigger and longer than those of the latter. "Kait Jingka" is however grown because of its very superior quality.

The most important problem in connection with the growing of bananas seems to be manuring. Farm yard manure, compost of village wastes, or leaf mould may be applied. The washing off of surface soil with rain water should also be prevented in all banana plantations.

Pineapple (*Ananas sativus*) is also a common fruit plaint in the Nongwar-Mawlong area and grows well in the orange

orhchards in partially sheltered situations, where the soil is well-drained and is fairly rich in humus material. The plants are propagated by offsets or "Suckers". Crowns from the fruit are also used but these take more time to mature whereas suckers usually come into bearing in fifteen to twenty months. At least three varieties are recognized in the area : (1) Queen, (2) Ceylon, and (3) Local or Desi. The plantation may last for from six to eight years but replanting after three or four years is preferred.

Millets are found almost entirely in the plateau area only. Broom-corn (*Panicium miliaceum*) and fox-tail (*Setaria italica*) are the most common. Job's Tears (*Coix Lachryma Jobi*) is not very common. Finger millet (*Eleusine coracana*) is not generally grown in this area, but is grown on the slopes towards the valley of the Cherra State, an area which I was not able to visit at this time.

Of these millets, "broom corn" is preferred for eating purposes to "finger", "fox-tail", or "Job's tears". All these millets are cooked in the same way as rice. Job's Tears is sometimes ground into flour which is used for making small local breads known locally as "pu sohriew". For the purposes of making beer or liquor, finger millet is preferred to the other millets. Finger millet is also used for feeding cattle (cows) especially in the winter. The grain is fed after cooking. Cattle fed in this way are said to give more milk or to put on more flesh than those not so fed.

Cabbages and peas are the most common of the vegetable crops grown and are, as stated above, confined almost entirely to the Cherrapunji-Mawsmai-Mawmluh-Laitkynsew-Laitmawsiang-Laitduh-Phudumsning area, that is, in the Southern part of the plateau. These are winter crops. Peas are sown in January—February and harversted in March—April. Cabbages are sown in the nursery in October—November, transplanted in December and January, and are harvested in March—April. These two crops do exceedingly well in this area. With proper manuring the crops are quite healthy. Cabbage however is often attacked by certain caterpillars which are larvae probably of the "Cabbage butterfly" which possess yellow wings with dark spots on the wings and with a wing expanse of about 1½ inches. The caterpillars can be easily killed by spraying early in the season with "gammexane" or with any of the insect sprays which are known not to be injurious to human beings.

It seems that cabbages are also attacked by cutworms which are also known to attack potato seedlings. These are also

catterpillars of a noctuid moth, and come out only at night. The insects very often cut young seedlings at the foot of the stems. These insects may be controlled by using poisoned baits, such as a mixture of Paris Green, molasses and bran.

Other vegetables grown in the area are turnips, beets, radishes, brinjals, tomato, etc.

ANIMAL HUSBANDRY.

Cows, pigs, poultry, sheep and goats are all common but not plentiful in the area. Cow's milk at the time I visited the area was quite scarce. This was especially due to the epidemic of foot and mouth disease which seems to visit the area almost every year. Proper instructions as to how to combat the disease may be issued to the cultivators in the form of pamphlets or through newspapers.

IMPLEMENTS.

The "mohkhiew" and "dao" are the only agricultural implements used. There are two types of "mohkhiew" (hand hoe) : (1) the "mohkhiew koidi" or "prisoner's hoe" which is probably one that was introduced to the area through jails, and (2) the "mohkhiew khasi" or "Khasi hoe" of which there are three sizes : big, medium, and small. The big size is used on sod land for turning over sods for potato fields in "jhum" cultivation, or for paddy lands. The small size is used mostly for weeding or for interculture and also for planting potatoes. The medium size is used either for turning over sod or for earthing up potatoes, etc.

MANURING.

The cultivators of this area are acquainted with the value of cowdung as manure. But the method of keeping cowdung is very wasteful. The dung is generally piled outside the barns very often directly under the eaves of the barn, so that rain water falls on it from the roof of the barn and washes away the valuable liquid manure, the little that is left in the dung. Occasionally the dung is collected in a pit which is dug just below the eaves of a barn. Both these methods are extremely bad. The cultivators should learn that the most valuable part of the manure is the urine. This should be conserved. Several precautions may therefore be taken in order to conserve the urine. In the first place dried grass or vegetation of all kinds may be spread on the floor of the barn so that it will absorb the urine. This grass is then collected and piled with cowdung. If possible

the liquid manure from the barn may be allowed to flow into a pucca pit where it is collected and either made use of directly in the fields or poured on top of a compost heap described herewith. The cowdung removed from the barn should be piled outside on a raised ground in the rainy season, or in a pit in the dry season. If grasses or vegetable wastes are available, these should be spread on the floor before putting the cowdung. Alternate layers of grass and cowdung are then put in a heap until it is about 3 to 4 feet high. The heap should be so made that very little rain water in the rainy season gets inside the heap. It is therefore desirable to have the heap covered with straw or any other material in the rainy season. The principle to follow is not to allow the pile to be too wet or too dry. This method of making manure is known as composting. In about three or four months the manure will be ready for application.

Some cultivators, especially in the northern part of the plateau, use some bonemeal and oil-cake in their fields. This is to be recommended whenever it is found to increase yield. Some cultivators are of the opinion that the addition of oil-cakes has a bad effect on the physical condition of the soil. This is doubtful.

Demonstration farm.

A small demonstration farm run by the Cherra State and located near the Headquarters of the ruler of the state would, in my opinion, stimulate agricultural development in the area. While this farm would serve mostly this vegetable area referred to in this report, yet one interested in the welfare of the state, if put in charge of this farm, would find time to visit other areas of the state quite frequently.

WAR ON THE POTATO BLIGHT*

By

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Potato blight is caused by a parasitic fungus, *Phytophthora infestans*, which flourishes best under mild and extremely moist conditions. The climate of Britain frequently provides these conditions, and when they persist for several days an attack of blight in the potato crop is likely to follow. But the weather is notoriously inconsistent, and although blight conditions often occur, their duration is normally insufficient to cause extreme epidemics comparable with those experienced in 1845 and 1846. In those years the crop was almost a complete failure, resulting in famine and misery in many parts of the country.

Since that time blight has been a permanent, if intermittent scourge, waiting only on suitable conditions to continue its war against the potato. It has been responsible for severe losses on many occasions, such as those experienced in 1916 during World War I, when food production was a major concern and in 1931 and 1936, when world conditions were less critical. Only occasionally during the last 100 years could damage by blight be described as negligible.

Protective Treatment

A recurrence of damage on the scale experienced in 1845 and 1846 must now be regarded as unlikely on account of the protective measures available to growers. Methods of combating the disease have been known for about 60 years, and although these have not been consistently applied, they have saved innumerable crops from extensive damage. Farmers, as a whole, may have been slow to adopt routine protective treatment, but any hesitancy on their part must be attributed to the irregularity of outbreaks in Britain's uncertain climate and the consequent risk of incurring unnecessary expenditure.

In recent years the greater efficiency of spraying equipment has tended to increase the use of chemical controls, particularly amongst the specialist growers. Protective fungicides are more widely applied by "ware" growers in order to obtain maximum yields of sound tubers. Seed growers, on the other hand, desiring smaller tubers, can usually achieve their object by killing the crop with a lethal spray such as sulphuric acid or sodium chlorate before the disease has reached the tubers.

* Issued by : British Information Services.

If the date of outbreaks could be accurately forecast, protective spraying would no doubt be extensively and more effectively applied. With this end in view, research work has been instituted to study the relationship between climatic trends and the manifestation of the disease, so that growers may be advised beforehand of the critical time to spray their crops.

Immune Varieties

Although fungicidal treatment, properly applied, can be highly efficient in controlling disease, it is clear that the ideal means of solving the blight problem is the production of immune varieties. Since the middle of the 19th century breeders have been searching for resistant types among the potatoes available to them, but they only succeeded in proving that the necessary qualities did not exist in any of the varieties in commercial cultivation.

The search was continued among related species of the potato, and it resulted in the introduction of a few wild species from Central and South America. Eventually, in 1909, Salaman in Cambridge demonstrated that resistance to blight did exist and that the character was inherited. Further wild species were introduced and employed in breeding experiments which, by 1926, provided a collection of seedlings possessing reasonably good economic characters, together with complete resistance to the blight fungus present in commercial crops.

Apparent Breakdown

It was thought then that the production of blight immune varieties suitable for commercial purposes would follow within a few years, but in 1932 many of the so-called resistant seedlings were attacked by the disease. This apparent breakdown of resistance was found to be due, not to any change in the host plants, but to the appearance of a new specialised strain of the parasite. Further new strains have since appeared, and have proved capable of attacking some of the seedlings which were resistant to both the common strain and the specialised strain in 1932.

Past experience thus shows that the breeding of a resistant potato variety is liable to be followed by the appearance of a new strain of the parasite capable of attacking it, a situation which is comparable with that of the rust fungi in relation to wheat.

But perhaps this comparison is not yet justified. The wart disease fungus (Synchytrium endobioticum) has also produced specialised strains, yet some old potato varieties have remained free from the disease for over 40 years. It is probable that the

future prospects for blight resistance occupy an intermediate position between that of wart immunity in potatoes and rust resistance in wheat.

Resistance to Blight

Resistance to blight is now known to be a complex which may conveniently be divided into two distinct parts: resistance to infection, and reaction after infection has taken place. The former, illustrated by the different degrees of damage caused in ordinary commercial varieties, and by the comparatively weak growth of the fungus in certain wild species, can provide only partial protection. In the second type, exemplified by the wild species S. demissum, resistance is manifested by the hypersensitive nature of the plant's cells. After infection of such a plant has taken place, the cells react quickly and the fungus is destroyed in the necrotic tissue formed at the point of entry of the parasite. Such plants are virtually immune because the only evidence of infection is the presence of tiny necrotic spots, and the amount of damage caused is negligible.

This characteristic appears to provide a means of combating the blight fungus, and breeding experiments are in progress to combine it in varieties suitable for commercial purposes.

Greatest Obstacle

The greatest obstacle to success is, of course, the ability of the parasite to produce new specialised strains, and therefore a degree of resistance in the plant must be built up against which all possible strains are powerless. It has been found that the hypersensitive condition in S. demissum is controlled by at least four major independent genes (hereditary units) each of which confers adequate resistance to a particular group of biotypes of the fungus. In the course of breeding work, involving hybridisation and repeated backcrossing to commercial varieties, these genes become separated. In every case where only a single gene is present, the variety has been attacked by a new specialised strain. A combination of two particular genes provides resistance to all the known strains of the parasite, but it is possible that these types may eventually succumb.

The ultimate aim is to recombine all the genes and so reproduce in full, in commercially acceptable varieties, the resistance qualities of the original wild species. Such a recombination of genes by modern breeding methods appear to be a practical proposition, and considerable progress has already been made towards its accomplishment.

SILAGE

By

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Introduction.

The feeding of livestock, with green and succulent feed, during the summer months has been one of the major problems of dairy farming in this country throughout our history. During these two to four months there is no fresh fodder available except on irrigated land and animals have to subsist during this period on supplies of dry fodder. In order to utilise economically the fodder which is available during other months, we should consider the possibilities of preserving fodder crops. There are various processes of preserving fodder in vogue in this country. Silage making is one of them. The process of 'ensilage' consists of preserving green forage crops in succulent condition for use out of season. 'Silage' is the name given to the product so obtained and a 'silo' is the container in which the silage is made. There is little doubt that this process is of great antiquity. As early as 1786, history records that the Italians preserved green crops for their animals by storing them in underground pits.

While silage is frequently seen at State demonstration and experimental farms and some very modern private farms, its value appears practically unrecognised in our villages. There is an urgent need for popularising this method of fodder preservation.

Crops Suitable for Silage Making.

Maize and the sorghums are the ideal silage crops. At the proper stage they contain enough sugar so that sufficient acid is produced in the silage frementations to make silage of high quality. Forage crops vary in their suitability for making silage and according to Lander (5) the best for Indian conditions is perhaps maize, although he has made very satisfactory silage from berseem, *jowar*, oats and also from sheesham (Dalbergia sissoo) leaves as an experimental famine fodder.

The sweet sorghums and grain sorghums or a mixture of oats and beans in the proportion of two of oats to one of beans makes an excellent and nutritious silage. Good silage can also be prepared by napier, guinea grass and sunflower. With these crops there is no need whatsoever of adding a preservative as molasses or mineral acid.

Legumes when ensiled alone are not as satisfactory as maize, because they contain but little of carbohydrates. This diminishes the intensity of acid fermentation. This defect can be overcome to some extent by allowing the legumes to wilt before ensiling or by mixing them with forage of high sugar content.

The best time to cut maize and oats and the sorghums for making silage is at the milk or flowering stage, before much fibre has developed.

Requisites of Good Silage.

To produce satisfactory silage the green forage crop must have certain definite characteristics. First of all it must be neither too dry nor too high in moisture content. If it is too dry it will not pack sufficiently in the silo and enough air will remain to permit the development of moulds. If the forage is too high in moisture, the silage is apt to be very sour or it may even spoil.

To make the best silage the forage crop should have solid stems, so that only a small amount of air will remain in the mass after it has settled. The small grain crops with their hollow stems do not possess this quality. Hence in ensiling such green forage it is specially important that the cut material be packed well by sufficient tramping to exclude the air to a very great extent.

It is essential that enough acid be produced in the silage to prevent the growth of undesirable bacteria that will cause rotting or putrifaction. The forage, must, therefore contain sufficient sugar or other carbohydrate which can be used by the acid-forming bacteria.

How Ensiling Preserves Green Forage.

The process of making silage is one of fermentation, and the whole art of making good silage depends upon controlling the fermentation within fairly narrow limits.

This is how the process works. When green forage from a suitable forage crop is packed into a silo, the cells of the plant are still alive and continue to respire or breathe, rapidly using up the oxygen of the air within the mass and giving off carbon-dioxide. Within five hours, practically all the oxygen has been used up and it is this which prevents the growth of moulds which are unable to grow in the absence of oxygen. Respiration is always accompanied by a rise in the

temperature when the material may be noticed 'heating'. As a result of this increase in temperature and the exhaustion of the air entrapped in the mass, the plant cells die and bacterial changes then set in.

On its leaves and stems, the crop carries large number of bacteria which now begin to multiply rapidly, using the sap of the dead plant cells for food. At the end of two days each gram of silage juice may contain one hundred billion bacteria. These bacteria attack the sugars in the green forage, producing organic acids, chiefly lactic acid, the acid present in sour milk, with some acetic acid, the acid of vinegar, and traces of butyric acid, that which gives rancid butter its pungent and obnoxious odour. Of these acids, lactic will be the dominant one in good silage and usually constitutes from 0·5% to 2·0% of the fresh weight of silage.

When the acidity has reached a certain degree the bacteria get inactivated and the fermentation is checked and finally the action practically ceases. If air does not gain entrance into the mass of silage, it will then keep for a long time with but little change. If air does penetrate, the moulds will grow and destroy the acid. In making silage, therefore, the lactic and acetic acid producing organisms, *i.e.*, *Streptococcus lactis and Bacterium acetii* have to be encouraged, by means of proper packing and a judicious occlusion of just the right amount of air to encourage their activity. When properly prepared the silage has a sweet or fruity taste. Such silage is very palatable to cattle.

Types of Silage.

Lander (5) mentions an intensive study of the quality of silage which was made at Cambridge by (*a*) inspecting silage from a large number of silos and ascertaining the conditions under which each was made and (*b*) by making accurate observations of the conditions of the crop as ensiled and subsequently observing the types of silage produced. In this way it has been possible to distinguish five distinct types of silage :—

(*i*) Sweet, dark brown silage,

(*ii*) Acid, light brown or yellow brown silage,

(*iii*) Green fruity silage,

(*iv*) Sour silage of several forms, and

(*v*) Musty silage.

The chief characteristics of these are briefly described as follows :—

I. Sweet, dark brown silage : This is a good feeding stuff but it is not the best type of silage. It has a sweet pleasant smell but it is rather dry, although it is very palatable and readily eaten by cattle. This type of silage is generally produced when the temperature rises above 113°C, but is not produced below that temperature. This frequently occurs when dry crops or those which have been allowed to dry after being cut are ensiled. Such crops facilitate fermentation because they cannot be very tightly packed and also because the heat generated by fermentation has less moisture to heat, hence the temperature rises. Considerable waste occurs with this type of silage due to excessive fermentation although the produce is both attractive and nutritious.

II. Acid, light brown or yellow brown silage : This type of silage is generally produced when oats or other cereal crops are used, specially if they are wilted shortly before being ensiled so that the crop contains from 25% to 30% dry matter when ensiled. The maximum temperature attained varies between 86° F. and 104° F., Brown silage is brown or yellow-brown and the more yellow the colour the better is the silage. It has a pleasant acid smell due to the presence of acetic acid. This silage is readily eaten by livestock and is one of the best types of silage.

III. Green fruity silage : This type is not very common but may be produced if crops are cut before maturity, at the milk stage before the seeds are properly formed. To produce this type, the crop should be cut and ensiled without delay. The maximum temperature attained is bout 86° F. and the resulting silage which has a green or olive green colour has an attractive smell, is neither sweet nor sour and is relished by the cattle. It is highly digestible also.

IV. Sour silage : Sour silage generally results when very immature and succulent crops are ensiled as the watery fodder packs down very closely in the silos and excludes air so that little rise in the temperature is possible. It is generally dark brown and has a pungent and unpleasant smell, chiefly due to the presence of the butyric acid.

V. Musty silage : Musty silage is frequently found at the top and the sides of the silopits. Owing to the excess of air present in the pits when the silage is not packed, properly normal formentation cannot take place, and consequently, moulds develop.

Cost of Production of Silage.

Ian Moore (7) is fully justified when he says that nothing is more difficult to cost than a farm crop because one cannot begin at the fixed point and end at another clear-cut point. Such arbitrary costs as 'overhead chages' should strictly be taken into account. In case of silage, quite apart from variation in the cost of growing the crop—be it, maize, *jowar* or berseem—the actual cost of ensiling is of prime importance.

Very little literature exists in our country on the cost-of-production studies of silage. However work by Yashpal C. Gupta (3) is worth mentioning. The calculations given by him are under conditions at the karnal substation of the Indian Council of Agricultural Research. The silo pits under this study were 6 feet deep, 30 feet long and 19 feet wide. The cost of turning green forage into silage came to about 2 annas per maund in 1946. This included charges for cutting, hauling, filling and closing the pits. Besides this a spoilage amounting to 10% was also taken into account while determining the cost.

While preparing silage other factors like capital investment, depreciation, and interest are to be considered. Silos of the dimensions given above would require 3,460 cubic feet of earth to be dug. The charges for this work, according to the Public Works Department in 1946, were about Rs. 42. This pit is considered good enough for ten years. Taking into account the cost and life of the silo, annual depreciation would be just over Rs. 4 a year and that this plus the interest and the cost of repairs would come to about Rs. 10 a year. One such pit will hold about 1,800 maunds of green fodder. So the cost of depreciation, interest and repairs comes to about 1 pie per maund of green fodder.

According to Yashpal C. Gupta (3) the cost of producing green *jowar* in 1946 for making silage was calculated as 3½ annas per maund. So, adding all these costs, the cost of production of one maund of silage comes to 6 annas approximately. The details are as follows :—

	Rs.	a.	p.
Cost of producing green *jowar* for silage making ..	0	3	6
Cost of making silage ..	0	2	0
Cost of depreciation on capital, interest and repairs ..	0	0	1
Total cost ..	0	5	7

Estimates of cost of production of green *jowar* at the Allahabad Agricultural Institute farm in the recent years have been varying form annas 12 to Re. 1. So according to present conditions one can expect the cost of production of silage to vary from annas 14 to Rs. 1-2-0 per maund.

Feeding of Silage to Livestock.

Silage is a succulent food comparable in feeding value with the crops from which it is made. The quality, however, varies greatly according to how and when it is made and the type and condition of the material of which it is composed. Good silage has certain desirable qualities quite a part from its nutrient content and retains its vitamin A content better than hay. It is very palatable and stock will eat more roughage when fed silage and roughage, than when they are fed dry roughage alone; this may make a considerable saving in the amount of concentrate needed. Morrison (6) recommends the following amounts of silage which can safely be fed to various classes of livestock as part of substitue for other part of the rations: Dairy cows: (in milk) 30 to 50 lbs.; somewhat less for dry cows; Dairy heifers, 12 to 20 lbs.

TABLE I.

Nutritive Values of the Various Materials from which Silage is Prepared.

(Adapted from Lander.)

(Silage prepared and tested at Lyallpur.)

Silage	Dry matter %	Digestible protein%	Total Digestible Nutrients %	Nutritive Rotio1:—	Calcium Cao %	Phosphorus P205 %	Potassium K20 %
1. Berseem ..	24·0	0·7	10·3	13·0	..	..	..
2. Guara with wheat *bhusa*.	30·5	1·0	14·1	12·6	..	..	..
3. *Jowar* (dough stage)	34·8	..	18·4	..	..	..	..
4. Maize (milk stage)	25·5	0·9	15·7	15·7	..	..	..
5. Oats (milk stage) ..	27·9	1·3	17·7	12·6	..	..	..
6. *Senji* ..	29·8	0·6	15·1	23·4	..	..	..
7. *Shisham* leaves ..	27·9	2·4	10·5	3·3	1·54	0·12	0·49
8*. Sweet Sorghum ..	25·1	0·8	15·1	17·9	0·07	0·04	0·24

*Morrison—Feeds and Feeding. pp. 976—977, 20th Edition, 1946.

Types of Silo.

A detailed account of various types of silo is considered out of the scope of this article, but the best under Indian conditions will be discussed.

Various types of silo may be used depending on local conditions. The best type is the tall cylindrical tower which may be made of wood or concrete and should be constructed so that the walls are air—tight, smooth and perpendicular in order that the fodder as it is placed in the tower can settle down into a campact mass.

A cheaper form of silo more suitable for Indian conditions may be made by digging a cylindrical pit in the ground comparable in some ways with the above-ground silo tower. This pit can be made without any capital expenditure other than that of the labour involved in making the pit. The dimensions of the pit will be governed partly by the number of animals and partly by the nature of the soil. Lander (5) has used *kachcha* silos 6 feet and 8 feet in diameter and 12 feet in depth. Such silos when filled held from 125 to 130 maunds of green fodder. It is very necessary to pack the pit very carefully and to give some form of lining to a *kachcha* silo pit to prevent silage at the circumference from being spoiled.

The pit may be of any shape but Das Gupta (2) suggests that a rectangular shape is preferable. This is commonly known as the trench silo. The depth and width are generally kept equal; the depth should not be less than 8 feet. The sides of the pit must be made smooth so that the exclusion of air may be easy and compression may not be interfered with. The length may be twice or three times the width or the depth. The corners must be rounded off. It is an advantage to have several pits rather than one very large pit.

Very small pits are uneconomical as some fodder is lost in surfaces of contact with the earth. Large pits on the contrary take too long a time to fill or empty out. The appropriate size may be calculated from the requirements of storage. A cubic foot will hold eighteen seers of green fodder at the time of filling. There will be shrinkage and losses depending upon the moisture content and state of maturity of the fodder at the time of filling.

Taking the shrinkage to be one third, one cubic foot when packed will give 12 seers, wet material at the time of feeding. A pit measuring 8 ft. deep × 8 ft. wide × 10 ft., long, will

give 640 cubic feet. If it is stacked on top in a slope it will hold one-third more. Such a silo is expected to feed a unit of 10 head of cattle for about 1½ months, more or less, depending on the size of the animals.

Site for the Silo Pit.

It is most important to select a site for the silo pit. The most essential point is that the bottom of the pit should be at least a few feet above the water level during the rains. If this is not assured water will percolate from the sides and spoil the silage. The site, therefore, should be chosen with great care, preferably on a maund and should have very good drainage.

The site may be near the cow shed from where the silage could be issued for consumption without engaging great amount of labour for haulage. For larger pits for big herds a site in the fields where the fodder is grown is usually selected. The filling operation becomes easy there. For use, the silage has to be carted away to the byres.

Filling the Silo Pit.

The pit may preferably be sheltered with a light rain-proof structure at the time of filling, for, if there is rain at the time of filling it will spoil the silage. When the silo pit is entirely filled up, it is well to ram it down by men and then allowing the bullocks to tread over and press down the materials. When an old pit is used all decayed matter and sludge should be cleaned out and then the pit should be repaired.

The top of the pit should be heaped with fodder like the slanting roof of a house. An incline of 45 degrees is preferable. This slope is also to be rammed and pressed down. Over this a 6 inch or one foot-layer of ordinary dry leafy stuff or straw should be piled up.

Opening the Pit.

One has to be particularly careful in opening the pit Only a small opening is to be made at the commencement and only that quantity that is needed for the day may be taken out. The withdrawal should be gradually along the whole width and in sections reaching down to the bottom. If two feet along the length has been opened, then two feet should be taken out down to the bottom layer. During the emptying operation also care about the exclusion of air is to be taken as far as possible. It is for this reason that the necessity of storing in a number of small pits arises, so that a pit once opened may be finished off quickly.

Spoiling of Silage.

Two types of spoiling are found in silage. The most common is moulding. The other is rotting. Both forms of spoiling require the presence of air before they can develop. The main factor, therefore, in preserving silage is the complete exclusion of air. Air cannot be excluded unless the forage is of proper moisture content and well packed. Mouldy silage, unless around the sides and top of the pit, nearby always indicates a lack of sufficient moisture at the time of filling.

The rotting of silage appears when air gains access to silage having plenty of moisture. It is usually found near the top in case of pits or doors in case of tower silos, and may be accompanied by the development of considerable heat.

Advantages of Silos.

There are a number of advantages that go with the use of the silo, but the greatest of all is the possibility it affords in providing moist and succulent fodder in seasons when green fodder is scarce. A succulent feed is absolutely necessary for the most economical production of milk. Silage provides it for summer feeding better than other feeds available during those days. The vitamins are better preserved, and the silage makes a very palatable feed which has a beneficial effect on the digestion of cows.

More nutrients can be grown on an acre used for silage, than an acre used for any other forage crop. This is well illustrated in Table II, which is under U. S. A. conditions.

TABLE II

Estimated crop yields, digestible nutrients and Milk Production per acre.

(Adapted from Henderson, Larson and Putney.)

Crop.	Pounds per acre.	Digestible protein, lbs.	Total digestible nutrients lbs.	4 per cent milk lb.
Corn silage ...	12,000	180	2472	3862
Alfalfa hay ...	4,000	424	2012	3142
Corn, ear & stover	3,850	135	1960	3062

It is evident from this table that corn silage furnishes more nutrients per acre than any other crop. If silage is grown, more milk can be produced per acre than with other fodder crops.

There is less waste in silage than in crops handled in dry state. More than one-third of the total food material in the corn plant is found in the stover. When corn is husked in the field and the stover is fed, there is a considerable loss. When maize is husked in the ordinary way and the fodder left in the field, from 60—70% of the food value of the corn crop is taken with the ears, while from 30—40% remains with the fodder.

When the silo is used all the feeding value goes into the silo and the loss in feeding value due to fermentations and due to spoilage on the top and sides and the losses of the juices is just little over 9 % as found at the Wisconsin Experimental Station (U. S. A.). This in turn leaves 91 % of the feeding value of the crop as it stood in the field. The losses in the silo due to fermentation though considerable are much lower than those that occur when the fodder is exposed in the field.

Another distinct advantage of the silo is the large amount of feed that can be stored in a given space. A ton of silage can be stored in 50 cubic feet, while a ton of hay requires 400 cubic feet.

Silos provide a very succulent feed of high quality at a low expense for any desired season of the year. The weedy crops which would otherwise be thrown away may produce silage of good quality, the ensiling process killing practically all the weed seeds present.

Last of all, when any forage crop is ensiled, specially maize or jowar, the forage is removed from the land early so that it may be prepared for another crop.

Conclusion.

In recent years great progress has been made in the technique of the process of making silage and in the immediate future we may expect tremendous developments in the extent of the practice of ensilage.

Acknowledgment.

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BUFFALO—THE COW OF PONDS

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"*There should be in our opinion no relaxation in the efforts to improve the buffaloes*"—Royal Commission on Agriculture.

INTRODUCTION.

Next to the cow, the buffalo is the most important animal in Indian Agriculture. Milk production is the chief function of the buffaloes in India. But buffalo-bullocks are also yoked for draft purposes specially for heavy traction work. They are slow and sluggish, when compared with the bullocks of the draft breeds of other cattle. They are also less able to withstand the extreme heat due to lack of sweat glands and for that reason they are very fond of water. "Yoke a buffalo and a bullock together, the former will head towards a pool and the latter to a meadow", is a common country proverb.

CLASSIFICATION.

There are six most important breeds of buffaloes in India, which can be classified as follows :—

BOVIDAE

- Buffaloes
  - *Bubalus caffer* (Cape buffalo)
  - *Bubalus arni* (Indian buffalo)
    - *Macrocerus* (Long, straight and well thrown back horns) Nagpuri buffalo
    - *Spirocerus* (Much shorter but well curved horns)
      - Heavy type (Murrah and Jaffarabadi buffaloes)
      - Medium type (Mehsana and Nili buffaloes)
      - Light and smaller type (Surti buffaloes)
- Cows
  - *Bos taurus*
  - *Bos indicus* (Indian Cow)

Bubalus arni is said to be indigenous to India and the Indo-Malaya archipelago and is found wild in the swampy *terai* area at the foot of the Himalayas and in parts of Assam, Burma and Central India. The domesticated form of this species is found not only over the whole of India and the greater part of

the Straits Settlements but it has spread to Asia Minor and North Africa. It was introduced in the 6th century to Italy. It was in Syria in Neolithic times but may not have been domesticated until near Christian times. It also existed in the Atlas regions of North-Western Africa even after the Neolithic times.

B. Caffer is a savage buffalo species of South Africa. It has never been domesticated. It offers exciting and even dangerous sport to the big game hunters.

Of the Indian breeds of buffaloes, the breed Murrah which constitutes 20% of the entire Indian buboline strength, has done the best. The native places, milk production and the weights of mature males and females of some important breeds of Indian buffaloes are given in table I.

TABLE I

Name of breed	Native place	Milk production per lactation*	Weight of mature male(3)	Weight of mature female( )
Murrah ..	Southern Punjab and Delhi	6000—9000	1000—1800 lbs.	800—1600 lbs.
Nili ...	Valley of Sutlej river	5000—6000	1300 lbs.	1000 lbs.
Mehsana ...	Baroda State ...	4000—6000	...	...
Surti ...	Gujrat ...	4000—6000	...	...
Nagpuri ...	Nagpur ...	3000—5000	...	...
Jaffarabadi	Gir forests of Kathiawar	4000—6000	...	...

* The data are from the Government Military Dairy Farms.(5)

Importance.

There is no doubt that the buffalo is the most important milch animal of the village folks of India. In comparison to the cow, the buffalo is more resistant to diseases, it gives more milk with a higher fat percentage and has greater ability to utilize large amounts of roughage. These characteristics of the buffalo have made it most popular among the villagers of India.

Breeding.

Very little work has been done on the breeding of the buffaloes. Next to goats, buffaloes are the most neglected milch animals in this country. The reverence in which the cow is held in India and which is extended even to *nilgai*, simply because of its resemblance in name, is, however, denied to the buffalo which is more closely related. This is probably due to its dark dingy color which is not liked by an average Indian due to some supersition attached to it.

State help has been denied because of the policy of the Government in the past, and to some extent at the present time also, of breeding a dual-purpose animal. It has now been demonstrated that there are fundamental reasons against this policy*. To breed both draft qualities and milk into the same animal seems genetically impossible. According to the Royal Commission on Agriculture, the buffalo should be patronized for milk production and the cow for the production of draft bullocks. The dangers from the dual purpose breeding policy was rightly pointed by the Royal Commission on Agriculture in the following words :

"In attempting to secure more milk from the fine type of draft cattle still to be found in many parts of India, there is a real danger that the qualities which have in the past commended them to cultivators, will be lost."

Number.

Indian buboline strength is 195·72 lakhs, which is 32·3 per cent[1] of the total Indian cattle population and 83·6 per cent. of the world's buffalo population. Of these, 97·9 per cent[1] are domesticated in rural areas and the rest in urban. Buffaloes are distributed throughout India. However, the density of distribution varies from state to state.

The number of buffaloes per square mile in undivided India according to Das Gupta [2] was 34, including 42·6 in U. P., 29·7 in the Punjab, 18·7 in Bihar and Orissa, 16·8 in Madras, 14·9 in Bombay, 3·4 in Bengal, and 2·0 in Assam.

The distribution of the buffaloes for unit of human population is the highest in P. E. P. S. U. (25 buffaloes per 100 persons) and the lowest in Orissa (3 buffaloes per 100 persons). The all India average of density works out to be 13 buffaloes per 100 persons.

* This is the opinion of the author and it has nothing to do with the Institute breeding policy.

U. P. contributes 43·9 lakhs [1] to the buffalo population of India.

Milk Production

Buffalo milk is considered not suitable for infant feeding because of its higher percentage of fat and the bigger size of fat globules than cow's milk. However, Levine[4] reports that allopathic physicians in China prefer buffalo milk to cow milk for infant feeding, where modified milk is required. This is because of the ease with which it lends itself to modification. He states that 100 gms. of Chinese buffalo milk with 18 gms. of sugar made up to 300 gms. with water brings the composition of the modified milk very near to that of human milk.

The composition of buffalo milk varies from country to country as shown in Table III.[4].

Table III

	Specific gravity	Water (%)	T. S. (%)	Fat (%)	Non-fatty solids (%)	Ash (%)
Indian buffalo ...	1·0300	81·74	18·26	8·11	10·15	·82
Egyptian buffalo	1·0324	83·09	17·91	7·95	9·95	·78
European buffalo	1·0333	81·94	18·04	9·07	8·97	·88
Chinese buffalo	...	76·98	23·08	12·46	10·62	·88

For comparative study the detailed composition of buffalo and cow's milk are given below: [4].

Table IV

	Water (%)	Total. solids (%)	Solids-not Fat (%)	Fat (%)	Proteins (%)	Lact-ose (%)	Ash (%)
Buffalo milk...	81·74	18·26	10·15	8·11	4·33	5·00	0·82
Cow milk ...	85·28	14·72	9·05	5·67	3·60	4·69	0·72

Buffaloes do not do very well in Bundelkhand, Assam and Kashmir in India. This accounts for the low milk yield in Bundelkhand [445 lbs. per buffalo per annum[1]], Kashmir State [570 lbs. per buffalo per annum[1]] and Assam [315 lbs. per buffalo per annum[1]]. The best production area is Saurashtra, where the average milk yield is 2500 lbs. per buffalo per annum[1]. The average yield per buffalo per annum in the country is 1101 lbs.[1] or about two and a half times that of a cow [413 lbs. [1]]. In U. P., however, the average production per buffalo per annum is 1240 lbs. [1] which is twice that of a cow [625 lbs. [1]].

According to a recent survey of the Agricultural Marketing Department of the Government of India, the total gross production of milk in the Indian Union, has been estimated to be 5826·9 lakh maunds. Of this total, 50·2 per cent is buffalo milk. Among the states, U. P. [1] produces the highest amount of buffalo-milk, which amounts to 684·74 lakhs maunds per annum, *i e.* 26·1, per cent of the total buffalo milk production. Travancore produces the least amount of buffalo milk, which is 2·97 lakh maunds per annum [1] *i.e.*, ·01% of the total buffalo milk production. It has been estimated [1] that 205 lakh maunds of buffalo milk per annum are retained by producers for home consumption.

From the discussion above, it is to be concluded that the buffalo needs a large scale development. The sooner it is done, the better it will be for the milk situation of the country which is fast deteriorating.

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BOOK REVIEWS

Farm Book-keeping by Chater Sain Jain, 420 pp. 7½ × 5, 1950.

Published by the author, Indian Agricultural Research Institute, New Delhi, Rs. 5.

This book will be useful to students of agriculture and to well-to-do educated farmers. The book is divided into two parts besides the first two introductory chapters. Part I, consisting of nineteen chapters, deals with the principles of book-keeping including that in farm valuations; while Part II (eight chapters) is concerned with farm records and cost accounts. An appendix containing useful information and a glossary of technical terms has been added. The text is written in simple English and is well illustrated with examples and sample "rulings" of records and accounts. At the end of each chapter are suggestive questions and exercises.

Farm records and accounts are essential to find out the weak spots in farm organization and management. On the other hand, one should remember that mere book-keeping will not necessarily increase profits, for in practice the maintenance of farm accounts is a matter of marginal utility. Unless accounts are carried on to completion and analysed at the end of each financial year, the time spent on keeping records will not be profitabie. It is easy to forget this important aspect of farm accounts and advocate a complicated system of book-keeping for farms. As one goes through Farm Book-keeping by Mr. Jain, one gets the impression that if a farmer were to keep the accounts advocated, he would have no time to do other productive work. To suggest "Office Furniture Account," for example, in farm accounting is unrealistic. The place of farm inventory—the "balance sheet" of the farm—in all types of farm accounting is not clearly indicated. Property accounting is completely omitted. The book suffers from printing mistakes which it is hoped will be corrected in the next edition.

The book will supply the need in this country for a good book in farm accounting. It is a welcome addition to the meagre literature on the subject—H. S. AZARIAH.

FARMER AND STOCK-BREEDER, YEAR BOOK 1951, published by the Farmer and Stock-Breeder, Dorset House, Stawford Street, London, S. E. 1, which has just come out, gives a very vivid picture of the recent developments of the animal industry in Great Britain. The livestock industry of

Britain should feel greatly indebted to this very attractive and well illustrated publication which every student of animal husbandry should have on his desk. Although, the book gives information on agriculture and livestock developments of Britain, yet, it should be a great help to any livestock breeder of any country.

The book is very beautifully illustrated and has 376 pages, the price being 7s. 6d. It has four sections, namely, special articles, pedigree year in pictures, poultry and references.

The first section contains a number of technical articles on 'World Food Problems,' 'More Marketing Boards,' 'Access to the Countryside,' 'Better Buildings for Pigs,' 'Hormones against Weeds,' 'Calves Need Green Food,' 'Liquid Manure Losses,' 'Beet Harvesting Progress,' and 'The Year among Equipment,' written by leading agricultural scientists of the United Kingdom.

The second section entitled 'Pedigree Year in Pictures,' exhibits the photographs of the best animals of various breeds of cattle, horses, sheep and swine, which were shown at the various livestock expositions of Britain in the year 1950. The photographs are very well taken, which makes the animal show prominent and therefore this book is of special interest to all livestock breeders and students of animal husbandry.

The third section, although a short one, is completely devoted to poultry development. Only one article by Dr. Coles on 'Choice of a Poultry System' is included which is illustrated rather well.

The last, but not the least, section is devoted to references. This gives very valuable information regarding addresses and personnel of official bodies of Britain, farmers' organization, research and educational institutions, principal shows to be held in 1951, artificial insemination centres in Britain, etc., etc.

Besides all this, many farming operations are pictorially represented and very valuable information about livestock, dairy and agricultural equipments for sale, and standard rations for livestock is provided.

This book is useful, informative and very well presented and will go a long way in providing a clear picture of improvements in the livestock industry in Britain to all students of animal husbandry and livestock breeders—HARISH C. SAXENA.